Sampling Episode Report
Holland America Veendam
Sampling Episode 6503

Executive Summary

March 2006

EXECUTIVE SUMMARY

Sampling Episode Report for Holland America Veendam

This Sampling Episode Report describes the sampling and analysis activities to characterize wastewater (graywater and sewage) generated and discharged by the cruise vessel Holland America Veendam while in Alaska waters. This sampling took place from June 20 through June 25, 2004, under the direction of the U.S. Environmental Protection Agency (EPA). The sampling program is part of EPA's data collection effort to evaluate whether to develop wastewater discharge standards, under 33 USC 1901 Note, for cruise vessels authorized to carry 500 or more passengers for hire when operating in the waters of the Alexander Archipelago or the navigable waters of the United States within the State of Alaska or within the Kachemak Bay National Estuarine Research Reserve. EPA will use information from the sampling of this vessel and three other cruise ships in Alaska to characterize wastewater generated and discharged by large cruise vessels with advanced wastewater treatment systems.

EPA selected the Holland America Veendam to characterize the performance of the Zenon Environmental Inc. membrane bioreactor treatment system, an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration and ultraviolet disinfection. Samples were collected of various wastewater sources (laundry, accommodations, food pulper, and galley wastewater); influent to the treatment system (combined graywater and sewage); influent to the ultraviolet (UV) disinfection component of the treatment system; effluent from the treatment system; source water; wastewater treatment residuals (screening solids and wastewater biosludge); and incinerator ash. Wastewater source samples were collected for a single 24-hour sampling period, while samples of the influent to and effluent from the treatment system were collected for five consecutive 24-hour sampling periods.

Strap-on ultrasonic flow meters were installed near the sampling locations for laundry wastewater, influent to treatment, and effluent from treatment to collect flow data and, in some cases, to trigger automatic sampling machines. In addition, flow data were collected from the Veendam's in-line flow meters installed on the graywater and sewage feeds to the treatment

system (which, combined, represent the influent to the treatment system) and on the effluent from the treatment system.

Various sample collection methods (composite by flow, composite by time, grab, and grab composite) were used depending on the sampling point and analyte. Tested analytes included pathogen indicators (fecal coliform, *E. coli*, enterococci), classical pollutants, total and dissolved metals, volatile and semivolatile organics, pesticides, polychlorinated biphenyls, and dioxins and furans. Not all samples were analyzed for all target analytes.

The food pulper wastewater samples showed the highest concentration among graywater sources for the majority of analytes, most notably *E. coli* and enterococci, oil and grease, nutrients, and solids. Accommodations wastewater samples had the highest concentration for 11 of the analytes, including fecal coliform, organics, and several metals. Laundry wastewater samples showed the highest concentration for five analytes, including alkalinity and several dissolved metals.

Because of water conservation measures onboard cruise ships (such as vacuum toilets), key analytes such as pathogen indicators, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and total suspended solids (TSS) are found at much higher concentrations in the influent to the Veendam wastewater treatment system than in typical domestic wastewater. Of the 54 metal analytes tested for, 27 were detected in every influent to treatment system sample. Among the 365 target analytes for volatile and semivolatile organics, pesticides, and polychlorinated biphenyls, only 9 were detected in any influent to treatment samples, most at concentrations close to their detection limits.

The Zenon treatment system successfully removed almost all pathogen indicators (>99%) and most classical pollutants, metals, and organics. Two pathogen indicators, fecal coliform and *E. coli*, were not detected in any of the 15 effluent treatment samples, while one indicator, enterococci, was detected in 2 samples at close to the detection limit. The treatment system removed almost all BOD_5 (>99%), COD (97%), total organic carbon (TOC) (93%), settleable residue (>99%) and TSS (>99%). The treatment system reduced ammonia, total

Kjeldahl nitrogen (TKN, which measures both ammonia and organic forms of nitrogen), and total phosphorus by approximately 75%, while nitrate/nitrite levels remained relatively unchanged. The treatment system was highly efficient at removing particulate metals, and removed dissolved metals at an average of 37%. The treatment system removed most of the volatile and semivolatile organics to concentrations below detection levels.

The Zenon wastewater treatment system generates two types of residual waste: screening solids (from two coarse screens at the beginning of the treatment system) and waste biosludge (excess biological mass from the treatment system's bioreactor). Screening solids are collected monthly for disposal on shore. Waste biosludge is pumped to a double-bottom holding tank for overboard discharge outside of 12 nautical miles from shore. Most of the analytes detected in these residual wastes were also detected in the influent to the treatment system. For many analytes, concentrations in the screening solids and waste biosludge exceeded those in the influent to treatment, suggesting that these analytes are removed from the system in these waste streams.

On average, each person generated approximately 62 gallons of untreated sewage (17 gallons) and graywater (45 gallons) per day. The average discharge from the treatment system was approximately 58 gallons of treated wastewater per person per day.